To:- Phil Sallee - Seattle

c. D Gibbons

Re Input on Proposed Harmonisation Docs – 23rd PPIHWG Montreal

1 FAR/JAR I ----- No Comment
2 25.901(d) APU Report ----- No Comment
3 25.903(e) Combustor Burnthrough

In section 7, Engine Case Burnthrough Model, Rolls Royce believes that the default flame characteristics that should be considered should be 2000 deg C (3632 deg F). The value of 3000 deg F as a <u>default</u> is too low.

In section 8, based on some in service incidents, the words 'will generally fail in a very localised area' should be 'can fail under these conditions' etc. i.e. the effects need not be <u>very</u> localised and words which imply this should be removed.

4 25.903(e) ----- No comment.
5 25.905 ----- No comment.
6 25.934 ----- No comment.
7 25.934 ----- No comment.
8 25.943 ----- No comment.
9 25.1091 ----- No comment.
10 25.1093 ----- No comment
11 25.1141 ----- No comment.
12 25.1187 Drainage and Ventilation Report

Within the draft AC on page 5, in section 2 the words say that the drainage system is not expected to accommodate large leaks, and a flow capacity of 1 gall /min has been acceptable in the past. This statement seems to be in conflict with AC25.1189 para 7.1.A.1) which talks about massive leaks.

On page 7, (1) Ground Test, as in other area's of this report the use of 'gallons' and 'fluid ounces' should be clarified as US or imperial. (Liters is actually spelt Litres).

13 25.1189 Flammable Fluid Shut-off Means

In the AC in section 7.2, a volume of 0.95 litres or 1 US quart, is quoted as being non-hazardous, whereas in P-NPA-E-37 definition (f) the volume as non-hazardous is 0.25 litres. The values should be consistent, in addition, if a volume of 0.25 (or 0.95) litres is non hazardous, why is an individual volume of 3.75cl the maximum in 25.1187?

Regards, Gordon Cooper

DRAFT NPRM
DATED September 14,1998

This draft Notice is revised to include the comments from the July, 1998 ARAC meeting in Seattle.

[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

[14 CFR Part 25]

[Docket No. ; Notice No.]

RIN: 2120-

Engine Inflight Restart Requirements

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of proposed rulemaking.

SUMMARY: This notice proposes an amendment to the airworthiness standards for transport category airplanes to establish engine inflight restart requirements following the loss of all engine power. The need for a rule change is based upon review of service experience that shows cases of all engine thrust losses (flameouts or shutdowns) have occurred for various causes and the ability to restart engines was required to provide continued safe flight and landing. Review of FAA approved inflight restart envelopes for some newly certificated airplanes shows reduced engine windmill restart capability which has significantly increased altitude loss required to affect engine restart following all engine thrust loss. This information indicates there is a need to revise the inflight engine restart requirements to provide minimum engine relight capability within the airplane operating envelope following loss of all engine thrust. If adopted, this proposal would establish requirements for inflight engine restart capability following loss of all engine power for transport category airplanes.

These proposals were developed in cooperation with U.S. and European aviation industry task groups including the Aerospace Industries Association of America (AIA) and the European Association of Aerospace Industries (AECMA). These changes are intended to benefit the public interest by establishing a minimum standard for recovery following the flameout or shutdown of all engines.

DATE: Comments must be received on or before

ADDRESS: Comments on this proposal may be mailed in triplicate to: Federal Aviation Administration, Office of the Chief Counsel, Attention: Rules Docket (AGC-10), Docket No. 800 Independence Avenue SW., Washington, D.C. 20591, or delivered in triplicate to: Room 915G, 800 Independence Avenue SW., Washington, D.C. 20591. Comments delivered must be marked: Docket No. Comments may be inspected in Room 915G weekdays, except Federal holidays, between 8:30 a.m. and 5:00 p.m. In addition, the FAA is maintaining an information docket of comments in the Office of the Assistant Chief Counsel (ANM-7), FAA, Northwest Mountain Region, 1601 Lind Avenue S.W., Renton, Washington 98055-4056. Comments in the information docket may be inspected in the Office of the Assistant Chief Counsel weekdays, except Federal holidays, between 7:30 a.m. and 4:00 p.m.

FOR FURTHER INFORMATION CONTACT: Michael J. Kaszycki, Airframe and Propulsion Branch (ANM-112), Transport Airplane Directorate, AirCraft Certification Service, FAA, Northwest Mountain Region, 1601 Lind Avenue S.W., Renton, Washington 98055-4056; telephone (425) 227-2137.

SUPPLEMENTARY INFORMATION:

Comments Invited

Interested persons are invited to participate in this proposed rulemaking by submitting such written data, views, or arguments as they may desire. Comments relating to the environmental, energy, or economic impact that might result from adopting the proposals contained in this notice are invited. Substantive comments should be accompanied by cost estimates.

Commenters should identify the regulatory docket or notice number and submit comments, in triplicate, to the Rules Docket address specified above. All comments received on or before the closing date for comments will be considered by the Administrator before taking action on this proposed rulemaking. The proposals contained in this notice may be changed in light of comments received. All comments will be available in the Rules Docket, both before and after the closing date for comments, for examination by interested persons. A report summarizing each substantive public contact with FAA personnel concerning this rulemaking will be filed in the docket. Commenters wishing the FAA to acknowledge receipt of their comments must submit with those comments a self-addressed, stamped postcard on which the following statement is made: "Comments to Docket No. ." The postcard will be date/time stamped and returned to the commenter.

Availability of NPRM

Any person may obtain a copy of this Notice of Proposed Rulemaking (NPRM) by submitting a request to the Federal Aviation Administration, Office of Public Affairs, Attention: Public Inquiry Center, APA-430, 800 Independence Avenue SW., Washington, D.C. 20591, or by calling (202) 267-3484. Communications must identify the notice number of this NPRM. Persons interested in being placed on a mailing list for future rulemaking documents should also request a copy of Advisory Circular No. 11-2A, Notice of Proposed Rulemaking Distribution System, which describes the application procedures.

Discussion of the Proposals:

Following several all engine out incidents, the FAA held a public meeting in 1986 to discuss all engine out restart capabilities. Subsequently the FAA issued special conditions that established minimum restart requirements that were intended to maintain the level of safety on new type designs to that of earlier technology airplanes. The Joint Aviation Authorities (JAA) have already clearly defined the European engine restart requirements in ACJ of JAR-25. The JAA has published specific guidance regarding the minimum restart requirements within the Acceptable Means of Compliance and Interpretations-ACJ to the Joint Airworthiness

Requirements (JAR). The guidance includes; flight crew delay times for initiation of a start, guidelines for test altitudes, configurations, and airspeeds associated with starter assist and windmill restart of engines. Differences between the FAA special conditions and the JAA compliance criteria for showing compliance to 25.903(e) have resulted in two different standards for certification of transport airplanes. Thus, the objective of this proposed amendment is to establish a minimum standard for recovery following the flameout or shutdown of all engines.

Regulatory History

The inflight engine restart requirements for turbine powered airplanes are identified in §§ 25.903, 25.1351 and 25.1585 of the Federal Aviation Regulations (FAR). Sections 25.903 and 25.1585 requirements were developed from the engine inflight restart requirements of the earlier Civil Air Regulations (CAR) Part 4b. Paragraph 4b.401(c) required the ability for individually stopping and restarting the rotation of any engine during flight. This intention was further incorporated into Part 25, specifically § 25.903(e), which requires 1) the ability to restart any engine during flight must be provided, 2) an altitude and airspeed envelope must be established for inflight engine restarting, and each engine must have a restart capability within that envelope and, 3) if the minimum windmilling speed of the engines following the inflight shutdown of all engines, is insufficient to provide the necessary electrical power for engine ignition, a power source independent of the engine driven electrical power generating system must be provided to permit inflight engine ignition for restarting. In addition, FAR 25.1351(d) requires demonstration that the airplane can be operated for 5 minutes following the loss of all normal electrical power (excluding the battery) with the critical type fuel (from the standpoint of flame out and restart capability) and with the airplane initially at the maximum certificated altitude. For airplanes equipped with Alternating Current (AC) powered fuel pumps, this requirement has resulted in demonstration of the capability to windmill relight the engine while on suction feed with battery power for ignition with relight usually occurring at altitudes between 16,000 to 25,000 feet.

In addition, as stated earlier in CAR 4b.742(d), the recommended procedures to be followed in restarting turbine engines in flight are to be described, including the effects of altitude. This intention was also incorporated into Part 25, specifically § 25.1585(a), which states that information and instructions must be furnished, together with recommended procedures for restarting turbine engines during flight (including the effects of altitude).

Background

Since the introduction of turbojet and turbofan engines into commercial service newer technology high bypass ratio engines have been developed which improve fuel efficiency, reduce emissions, and improve engine tolerance to severe inclement weather conditions. However, some engines incorporating these improvements have shown a tendency to require increased airspeed to provide sufficient windmilling rotational energy to the engine core for restarting. When the existing Part 25 requirement was developed the engine windmill relight capability covered nearly the entire airplane airspeed and altitude operational envelope, including low altitude low speed conditions. Many newer technology engines that incorporate improved fuel efficiency, lower emissions, and improved tolerance to inclement weather conditions have demonstrated relight envelopes which in many cases are limited to higher airspeed conditions. In addition, other engine installations have been developed which utilize free turbine type engines that may require either an electrical or pneumatic power source for inflight restart.

These characteristics have resulted in a gradual reduction in the size of engine inflight windmill relight envelopes on some newer technology engines. Today many newer technology airplanes require starter "assists" from a pneumatic source such as another operable engine or an inflight operable Auxiliary Power Unit (APU) over a large portion of the airplane operating envelope.

The task group, consisting of AIA, AECMA, and FAA members, has assembled a list of over thirty all engine out events that have occurred between 1959 and 1997. Review of reported incidents of all-engine flameout or shutdown events on transport category airplanes indicates that a minimum engine restart capability is needed to sustain the current level of safety. The task group has recommended establishing a minimum engine restart capability for the all engine out case.

The data indicates that multi-engine flameouts or shutdowns have generally resulted from a common cause, such as fuel system mismanagement, crew action that inadvertently shutoff the fuel supply to the engines, exposure to common environmental conditions, or engine deterioration occurring on all engines of the same type.

Discussion

The current regulations were developed based on the understanding that turbine engines inherently had an adequate inflight windmill relight capability therefore, only an electrical power source for engine ignition was required to permit inflight engine restarting following an all engine flameout or shutdown. The reduction in restart capability that has occurred as new technology engines were developed was not foreseen when the restart regulations were promulgated. Several recently certified airplane types have a significantly reduced inflight windmill restart envelope, and assured recovery from an all-engine flameout or shutdown requires one of the following: (1) quick response from the flightcrew to restart the engines before the engine rotor speed falls below minimum values, (2) sufficient altitude to allow the flight crew time to achieve a high airspeed within the engine windmill restart envelope, or (3) an appropriate bleed air source such as an inflight operable APU to allow starter assisted engine restart.

The current regulations do not adequately assure successful inflight engine relight capability under certain circumstances, particularly during flight at low airspeeds and altitudes, following a multi-engine inflight flameout or shutdown. The FAA has concluded that a minimum level of restart capability is necessary to maintain an adequate level of safety for transport category airplanes.

The FAA has issued Airworthiness Directives requiring relocation of engine shutoff switches in one airplane type, increased inflight engine idle thrust levels during descent and subsequent engine modifications to another airplane type to reduce the likelihood of all engine out incidents occurring as described earlier. In addition, aircraft manufacturers have developed new flight crew procedures to achieve "rapid" relight of the engines following failure so that relight can be attained before the engine rotor speed falls below minimum values during the takeoff portion of the flight. The FAA is continually monitoring service difficulty reports to determine if AD action may be necessary on other transport airplanes that may exhibit unsatisfactory engine relight capability. Newer technology higher bypass ratio engines currently under development are expected to have inflight restart envelopes that require starter assisted relight capability over a larger portion of the present baseline envelope. The FAA proposes to revise the regulatory standard to provide an adequate level of safety.

Regulatory Options

Within the regulatory revision context, several options were considered by the FAA, including: (1) requiring a windmill start capability throughout an airplane's entire flight envelope thus alleviating the all-engine flameout/relight concern, (2) requiring additional equipment necessary to provide expanded starter assistance capability, such as start cartridges, (3) requiring certification of an inflight operable APU as an acceptable air source for starter assistance and thereby making APU's required airplane equipment and requiring either full time operation during certain portions of flight or demonstrated ability to start the APU when needed.

The proposed amendment does not specifically require or prevent any or all of the options presented above. The airplane manufacturer may investigate these options and any others for a suitable method to provide the required engine inflight restart capability.

Regulatory Intent

The FAA considers that a reasonable restart envelope must assure restart of the engines prior to a loss in altitude that would preclude continued safe flight and landing.

Several methods are available to an applicant that would permit a more responsive and reliable restart capability, such as providing an inflight operable APU within the restart envelope for engine starter assistance or providing engine modifications. Other methods may also be available to the applicant to ensure a reliable restart capability. Therefore the FAA does not require, within the proposed regulatory amendment, any specific method that would satisfy the minimum inflight restart requirement.

Future Advisory Circular

Many variables presently exist that influence the capability of turbojet engines to perform an. acceptable inflight restart, including: engine bypass ratio, altitude and airspeed/mach number, engine stability, outside air temperature, the presence of precipitation, idle rotor speed, shut-down duration (cold soak), engine time since overhaul, installed configuration (accessory loads); and engine fuel control/surge bleed valve schedules. These and other variables may equally affect the capability of a turbopropeller engine to restart during flight.

Although it is necessary for all engine installations to be flight tested to establish and demonstrate an engine restart envelope during flight, the FAA has not required each engine type to demonstrate restart capability under the influence of all variables affecting relight capability. Some technical experience and analysis may be necessary to determine those variables with the greatest effect on the engine restart capability and those that would reasonably need to be considered to assure continued safe flight and landing.

The group has also assisted the FAA in developing an advisory circular to identify and clarify acceptable means to demonstrate compliance with the regulation proposed within this 'notice. This AC will provide guidelines to be used by the airframe manufacturer for conducting a safety analysis to establish both the minimum required restart capability and assist in certification flight test planning.

Regulatory Evaluation

Regulatory Flexibility Determination

Under the criteria of the Regulatory Flexibility Act of 1980 (RFA), the FAA has determined that the proposed rule would not have a substantial economic impact on a substantial number of small entities.

Since the act applies to U.S. entities, only U.S. manufacturers of transport category airplanes would be affected. In the United States, the Boeing Company is the only manufacturer that specializes in commercial transport category airplanes. In addition, there are a number of others that specialize in the manufacture of other transport category airplanes, such as those designed for executive transportation. These include Cessna Aircraft Corporation, Bombardier, Raytheon, and Gulfstream American Corporation.

The FAA size threshold for a determination of a small entity for U.S. airplane manufacturers is 75 employees; any U.S. airplane manufacturer with more than 75 employees is considered not to be a small entity. Because none of the transport category airplane manufacturers is a small entity, there would be no impact on any small entity as the result of the implementation of this proposal.

International Trade Impact Assessment.

The proposed rule is not expected to have an adverse impact either on the trade opportunities of U.S. manufacturers of transport category airplanes doing business abroad or on foreign airplane manufacturers doing business in the United States. Since the certification rules are applicable to both foreign and domestic manufacturers selling airplanes in the United States, there would be no competitive trade advantage to either.

Federalism Implications

The regulation proposed herein would not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this proposal would not have sufficient implications to warrant the preparation of a Federalism Assessment.

CONCLUSION: Because the proposed provisions are not expected to result in a substantial economic cost; the FAA has determined that this proposed regulation is not considered to be major under Executive Order 12291. Additionally, as this document involves an issue that has not prompted a great deal of public concern, it is not considered significant under Department of Transportation Regulatory Policies and Procedures (44 FR 11034; February 26, 1979). Since there are no small entities affected by this rulemaking, it is certified under the criteria of the Regulatory Flexibility Act that this proposed rule, if promulgated, would not have a significant economic impact, positive or negative, on a substantial number of small entities. A copy of the initial regulatory evaluation prepared for this project may be examined in the public docket or obtained from the person identified under the caption, "FOR FURTHER INFORMATION CONTACT."

List of Subjects in 14 CFR Part 25: Aircraft Aviation safety, Engines, Restart.

The Proposed Amendment

Accordingly, the Federal Aviation Administration (FAA) proposes to amend Part 25 of the Federal Aviation Regulations (FAR), 14 CFR Part 25, as follows:

Part 25 - AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

1. The authority citation for Part 25 continues to read as follows:

Authority: 49 U.S.C. 1344, 1354(a)7 1355, 14217 1423,1424,1425,1428, 1429, 1430; 49 U.S.C. 106(g) (Revised Pub. L. 97-449; January 12, 1983); and 49 CFR 1.47(a).

2. By amending § 25.903 by adding a new paragraph (e)(4) that read as follows:

§ 25.903 Engines.

* * *

EXISTING WORDING SHOWN FOR COMPLETENESS

(e) *Restart Capability.*

(1) Means to restart any engine in flight must be provided.

(2) An altitude and airspeed envelope must be established for in-flight engine restarting, and each engine must have a restart capability within that envelope.

(3) For turbine engine powered airplanes, if the minimum windmilling speed of the engines, following the in-flight shutdown of all engines, is insufficient to provide the necessary electrical power source independent of the engine-driven electrical power generating system must be provided to permit in-flight engine ignition for restarting.

(PROPOSED AMENDMENT TO TEXT)

(4) For turbine engine powered airplanes it must be shown by test and analysis that a means to restart those engines needed for continued safe flight and landing of the airplane is provided following the flame out or shutdown of all engines.

Pratt & Whitney
Main Street
East Hartford, CT 06108

Pratt & Whitney

A United Technologies Company

To: Mr. G.P. Sallee
J.C. Tchavdorov

Date: September 21, 1999

Subject: P&W Comments on Proposed §25.903(e)

While Pratt & Whitney is sympathetic with the need for an all-engine out **inflight restart** requirement, Pratt & Whitney believes that the materials presented for the revised §25.903(e) are inadequate and should not be submitted as a PPHIWG endorsed position to the Transport Aircraft & Engines Issues Group. We also submit that this proposal is not appropriate for the fast-track process and should be tasked as a full rule-making project.

Rationale for this conclusion include:

1. The submitted materials rely on material developed by the AIA/AECMA Inflight Restart committee (PC345). This effort was prematurely terminated and its report submitted as a statement of status before there was technical agreement amongst the membership. The minority opinions or negative comments received on this rule making proposal are evidence of the lack of technical agreement.
2. A copy of the NPRM that is proposed to be submitted to the TAEIG has not been distributed to the PPIHWG membership for review as a component of this package.
3. The proposed new rule language (assuming the version from AIA/AECMA report is current), "[f]or turbine engine powered airplanes, it must be shown by test and analysis that a means to restart those engines needed for continued safe flight and landing of the airplane is provided following the flame out or shutdown of all engines", is inappropriately vague and sets forth a requirement that may be impossible to meet for any imagined circumstance. This rule language does not meet the intent put forth in the PPHIWG Report on 25.903(e) - Inflight Restart, "to amend the regulation to clearly address the all engine out failure condition and provide a minimum inflight re-starting capability to be achieved". The rule should clearly define the minimum safety standard by clearly specifying the condition(s) that must be addressed.
4. The draft Advisory Circular included in the PPHIWG contains a significant amount of regulatory material. This is not reflective of "a means, but not the only means" of compliance. Examples of this language include (but are not limited to):
   - Section 7: "Four conditions are to be addressed:"
   - Section 7 "Each zone must be identified in the Airplane Flight Manual. Sufficient tests must be carried out in each zone to validate it reliably."

- Sections 8.3 & 8.4: "The same *criteria* as in §8.2 should be used for times to relight & spool-up." (italics added for emphasis)
- Section 8.5: "... for compliance with any of the section 7 restart conditions..."
- Section 8.5: "- a minimum of 95% APU start reliability must be demonstrated by test..."
- Section 8.5: "- if an APU assisted engine start is used for complying with the Low altitude conditions I or IV..."

In addition to the above concerns, P&W offers the following technical comments on the proposed Advisory Circular. These items also indicate a general lack of maturity in the Advisory Circular.

1. Section 4.3: The indication "low altitude possible", included in the citation of volcanic ash experience should be deleted, as the discussion in this section should be restricted to a pure statement of history.
2. Section 7: The statement "...the applicant will be expected to show by test or analysis supported by tests..." is inconsistent with the proposed rule language, "...it must be shown by test and analysis...". The rule language should be modified to allow either test or validated analysis.
3. Section 6.1: The following guidance is provided: "Several manufacturers have implemented features which are intended to enhance safety by reducing the likelihood of engine damage during start or eliminating all engine flame-out events for specific causes. These systems may improve safety but should not be considered as eliminating the need for a safety evaluation of all engine power loss occurrences". However, this is contradicted by guidance under Section 7, item 4) which indicates that credit may be given for systems that minimize the likelihood of all engine out conditions. The text in section 6.1 should be modified to be consistent with Section 7.
4. Section 7, item 4): The text indicates that credit may be given for aircraft safety devices that minimize the likelihood of the all engine out condition ("aircraft design features which minimize the potential for inadvertent shutoff", automatic relight, and automatic sub-idle stall recovery systems). However, there is no additional guidance for the applicant on this subject, nor is this credit reflected in the "Acceptable Means of Compliance" listing in the table summarizing the compliance guidelines. Finally, there is no indication that the applicant can obtain similar credit for the presence of these safety systems for the other proposed compliance conditions. The summary table should be modified and credit for such systems should be extended to the other proposed conditions.
5. Section 7, item 4): No rationale is given for using 1.45 V_{STALL} (clean configuration) as the initial speed for the proposed condition. The typical flight speed for approach at 10,000 ft should be used as the initial speed.
6. Section 7: Condition IV in the summary table calls for a 250 KT maximum initial speed for the demonstration based on this being the maximum permitted airspeed below 10,000 ft altitude, However, there is ongoing activity to alter this restriction and this should be reflected in this proposed condition if the condition is retained.

7. Section 7: Condition IV in the summary table calls for a 250 KT maximum initial speed for the demonstration based on this being the maximum permitted airspeed below 10,000 ft altitude, However, there is ongoing activity to alter this restriction and this should be reflected in this proposed condition if the condition is retained.
8. Sections 7 & 8: The structure of the demonstrations proposed in the two sections is confusing. The interaction between the two sections is not always clear. For example, what is the relationship between the proposed high power demonstration under section 8.6(b) and that under section 7 items 1) &/or 2)? Restructuring of sections 7 & 8 of the Advisory Circular is required to clarify their intent and the associated demonstrations. Reference to the section of §25.903(e) to which compliance is being demonstrated should be added.
9. Section 8.2: Positive indication of normal start progression should be sufficient to demonstrate acceptable windmill starting capability. The time requirements should be removed from this section.
10. Section 8.3: Text proposes rapid relight demonstrations should be performed with "engine initially stabilized at idle". This is inconsistent with the take off case (section 7, item 1), where rapid relight is an acceptable means of compliance.
11. Section 8.6(b): The text "the engine should relight and reaccelerate to its original power without any crew actions other than selecting ignition and fuel" imposes an additional restriction on acceptable rapid relight procedures that is not present in other discussions of rapid relight acceptability. This text should be deleted.

Pratt & Whitney remains committed to the development of a regulatory requirement for all-engine out inflight restart. However, due to the concerns outlined above, we can not support the current proposal at this time. Instead, we recommend that this project be removed from the fast-track process and tasked as a full, cooperative government-

Michael Romanowski
Manager
Flight Safety, Certification, & Airworthiness
Pratt & Whitney

g **GE Aircraft Engines**

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October 19, 1999

Subject: 25.903e Response

To: GP Sallee/Boeing Commercial Airplane Group
JC Tchavdorov/Airbus Industrie
Mike McRae/Federal Aviation Administration
Robin Boning/Civil Aviation Authority

Ref.: 25.903e Response

It has become apparent that there is considerable technical disagreement over the contents of draft rule and AC 25.903e. (Ref. 1, 2, 3) In view of this widespread technical disagreement and the magnitude of the proposed departure from current industry practice, GE supports Pratt & Whitney's request that the draft rule and AC not be presented to TAEIG, and that this rule should be removed from the fast-track process and tasked as a full rule-making project.

In the interim, GE proposes that the Generic Special Condition (Ref. 4) continue to form the basis for demonstration of compliance with the intent of 25.903e.

References:

1 GE Minority Position on Proposed AC 25.903(e), September 17, 1999, S Knife to GP Sallee and JC Tchavdorov
2 P&W Comments on Proposed 25.903(e), September 21, 1999, M Romanowski to GP Sallee and JC Tchavdorov
3 Cessna Minority Position on Draft AC/ACJ 25.903(e), August 19, 1999, B Miles and R Barnes to GP Sallee and JC Tchavdorov
4 Generic Special Condition

Original signed by Bev Kersh for

Dr. Sarah M. Knife
Senior Staff Engineer - Industry & Regulatory Affairs
Flight Safety Office, GE Aircraft Engines

g

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Subject: Minority Position on Proposed AC 25.903 e)

Date: September 17, 1999

To: GP Sallee Co-chair, PPIHWG
JC Tchavdorov Co-chair, PPIHWG

This minority position documents areas of substantive disagreement which were raised within the working group, and which were not dispositioned at the time.

A. ALTERNATE MEANS OF COMPLIANCE

This advisory material is introduced "to maintain the current level of safety" (section 4.3) with respect to recovery from an all-engine power loss event. Improving the level of safety may be achieved by reducing the likelihood of the all-engine power loss taking place, or by improving the likelihood of aircraft recovery in the event of an all-engine power loss. It can be seen from Chart 1 that the incidence of all-engine power loss is apparently decreasing. It can also be seen that the incidence of such events in high bypass ratio propulsion systems is trending downward and is now very low compared to the overall fleet history. The improvement noted in Chart 1 may be attributed to the considerable efforts made by the regulatory authorities and industry over the last 10 years, to control the incidence of all-engine power losses, by changes to the engine and aircraft requirements and design to render the engine more robust to inclement weather and FOD. It would therefore appear from service experience that reducing the likelihood of the initial all-engine out event is an effective way to maintain overall aircraft safety.

It should be noted that some of these changes have rendered windmill start more difficult, so that it may take longer or only be possible in a smaller flight envelope. However, none of the all-engine power loss events have been unrecoverable due to a small windmill start envelope, or to slow spool-up times from windmill start.

It is suggested that the intent of the rule would be better met if at least partial compliance could be demonstrated by design provisions minimizing the likelihood of the initial all-engine power loss. It is therefore proposed that wording be added as follows:

7 - COMPLIANCE GUIDANCE

This section is intended to define overall restart performance that includes the use of power assisted and windmill restart capabilities and to describe acceptable compliance guidelines.

The effects of the loss of engine power from one, multiple and all engines must be considered. However, the loss of all engines generally determines the most stringent requirements in terms of restart capability, and the intent of the regulation will be satisfied by addressing this critical case.

In order to confirm that engine restarting can be achieved, in circumstances where all engines run down or are shut down, the applicant will be expected to show by test or analysis supported by tests that sufficient power/thrust can be restored to enable the airplane to achieve level flight without excessive loss of altitude. **For propulsion systems where design provisions have been made to address the majority of known causes of all-engine power losses at a given flight condition, the risk of an unrecoverable all-engine power loss will be considered to be greatly reduced, and therefore there is no need to demonstrate compliance with the altitude loss requirement for that flight condition .**

Four conditions are to be addressed :

1. Shut down from take off/climb power with pilot recognition time delay based on analysis of indications (inherent or dedicated indicators) to the flight crews. (Pilot recognition time has typically ranged from 5 to 15 seconds based on service data.) **Service events at this flight condition have resulted primarily from crew inadvertently shutting down all engines .**

Acceptable means of compliance include rapid relight procedures or starter assistance from an external power source. The altitude loss between initiating the restart and achieving level flight should not exceed 2500 ft.

2. An engine should be able to be restarted at a minimum altitude of 15,000 ft from a shut down at typical descent speed at 20,000 ft or above. **Service events at this flight condition have resulted primarily from engine icing and fuel system malfunction.**

3. The engine should be able to be restarted with an altitude loss not exceeding 5000 ft from a power loss occurring between 10,000 and 20,000 feet. **Service events at this flight condition have resulted primarily from inclement weather and engine icing, and have only occurred for descent power.**

The aircraft speed at the time of power loss should be representative of the normal flight profile (climb or descent) in this altitude range for the flight phase considered.

4. Flame out or shut down from descent power below 10,000 ft with a delay in crew action based on indications (inherent or dedicated indicators) to the flight crew of all engine power loss. **Service events at this flight condition have resulted primarily from inclement weather (rain/hail ingestion).**

A 30 second crew recognition time should be used if no dedicated indication is provided. Crew Recognition Time may be shortened based upon dedicated indications that engines have flamed out or rolled back to sub-idle, as well as aircraft design features which minimize the potential for inadvertent shutoff. Other factors which may be considered in the crew recognition time evaluation include automatic relight and automatic sub-idle stall recovery systems.

The initial airplane speed that should be used for the all-engine out restart evaluation is 1.45 Vstall (clean configuration) of the maximum landing weight of the aircraft. Acceptable means of compliance include rapid relight, starter assistance from an external source and stabilized windmill start. The airplane should not lose more than 5000 feet altitude between initiating restart procedures and achieving level flight. In addition, the maximum aircraft speed to achieve the restart should not exceed 250 kts.

B. BASIS FOR AC IN SERVICE EXPERIENCE

Section 4.2 states "The service experience supports the position that suitable engine restart capability must be available following the loss of all engine power to avoid an unsafe condition." A database of all events of complete engine power loss occurring in the commercial transport fleet[1] was compiled by the working group. Although detailed information on airspeeds and altitudes was not available for every event, the flight phase was available for 41 of the 50 events, giving a general indication of the flight condition. (Chart 2 shows the events by flight phase, with more detailed information added where it was available.) The data collected gives a statistically valid sample of all-engine power loss events, and can therefore be used as the basis for the conditions to be flown.

The flight conditions specified in the AC do not reflect the flight conditions at which the majority of all-engine power losses have historically occurred, according to this database. Specifically, condition 4 (low power, below 10,000 ft, 1.45 Vstall) reflects a more severe condition than has been documented for an all-engine power loss in the commercial transport fleet. It is proposed that the requirement of section 7, condition 4, for an initial airspeed of 1.45 Vstall be changed to permit a higher initial airspeed such as 250 kts.

C. CAPABILITY OF EXISTING FLEET

Since this advisory material is introduced "to maintain the current level of safety" (section 4.3), the conditions to be demonstrated should be within the capability of the majority (50%) of the existing fleet. It is not possible to establish from existing data whether the majority of the existing fleet could meet section 7, condition 1 (high power fuel cut and recovery within 2500 ft), but the limited information available suggests that most of the fleet could not demonstrate this condition. The alternate means of compliance proposed above (A) may provide some relief. It is proposed that the wording of section 7, condition 1 be changed as follows:

> Acceptable means of compliance include rapid relight procedures or starter assistance from an external power source. ~~The altitude loss between initiating the restart and achieving level flight should not exceed 2500 ft~~.

Chart 3 shows the minimum windmill start airspeed as a function of aircraft certification date. Half of the engine/airframe combinations currently in service are capable of windmill start, S/L, at 250 knots. Therefore a reasonable criterion for maintaining the current safety standard would be 250 knots rather than 1.45 Vstall. The following wording change is proposed to Section 7, condition 4:

> The initial airplane speed that should be used for the all-engine out restart evaluation is **250 kts**. Acceptable means of compliance include rapid relight, starter assistance from an external source and stabilized windmill start. The airplane should not lose more than 5000 feet altitude between initiating restart procedures and achieving level flight.

Sarah M. Knife Ph.D.

---

[1] Excluding military action and events where at least one engine was always running, although all engines were sequentially shut down in the flight, and excluding events where engine damage during the power loss prevented restart.

Senior Staff Engineer - Industry & Regulatory Affairs
GEAE Flight Safety Office

Chart 1

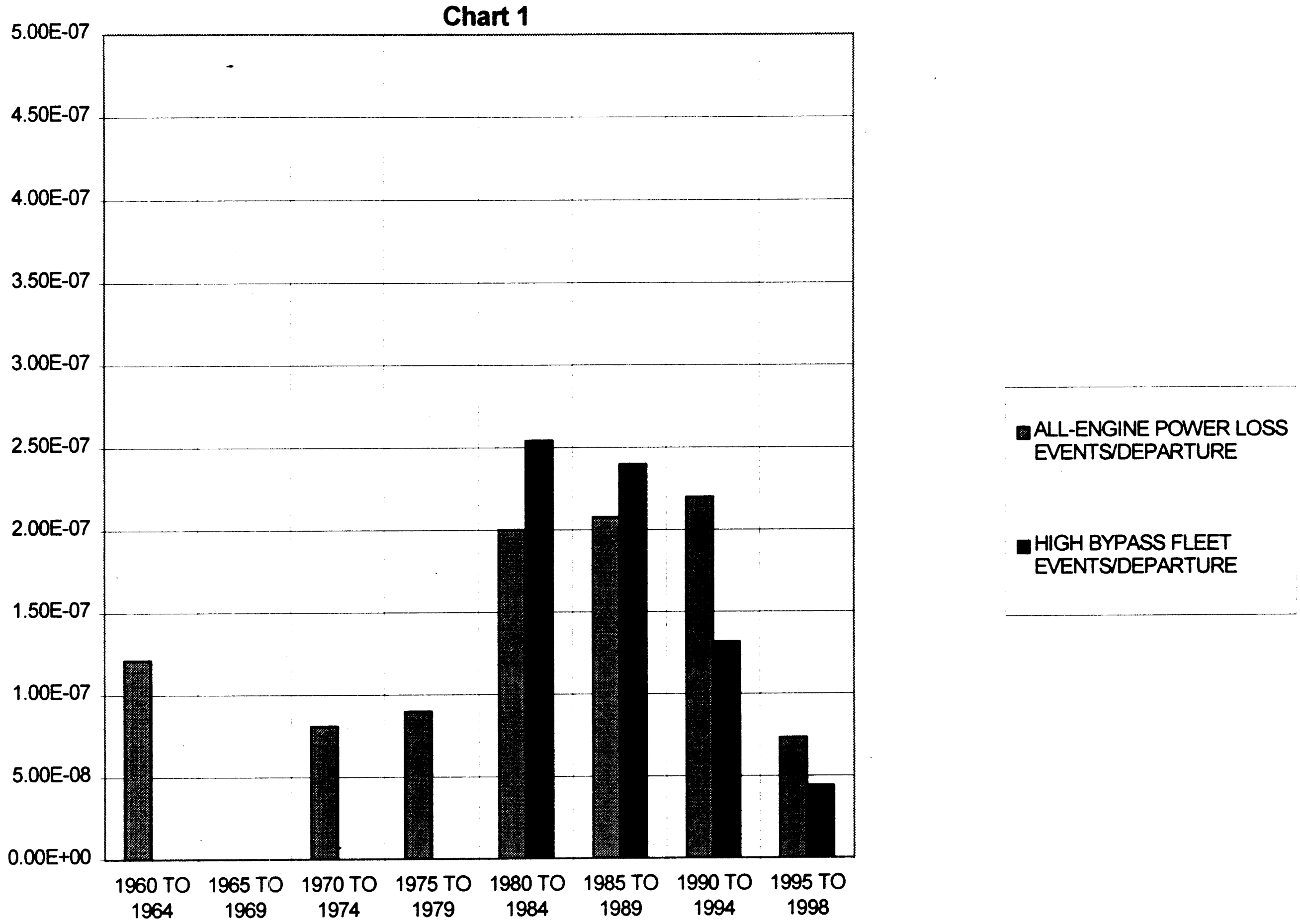
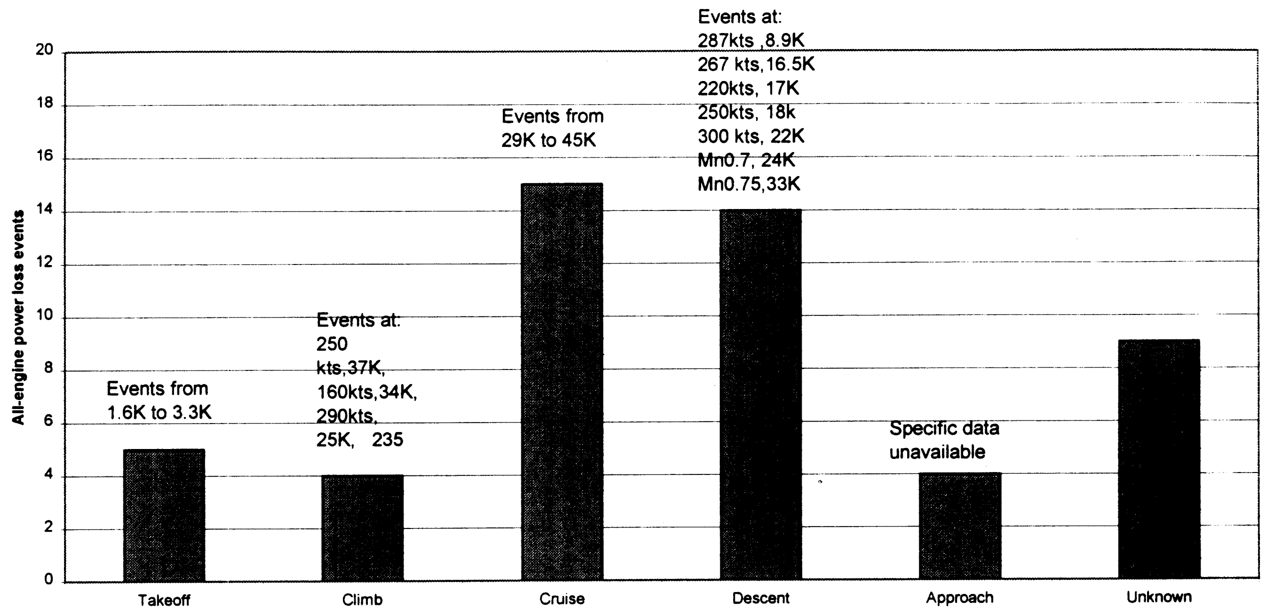
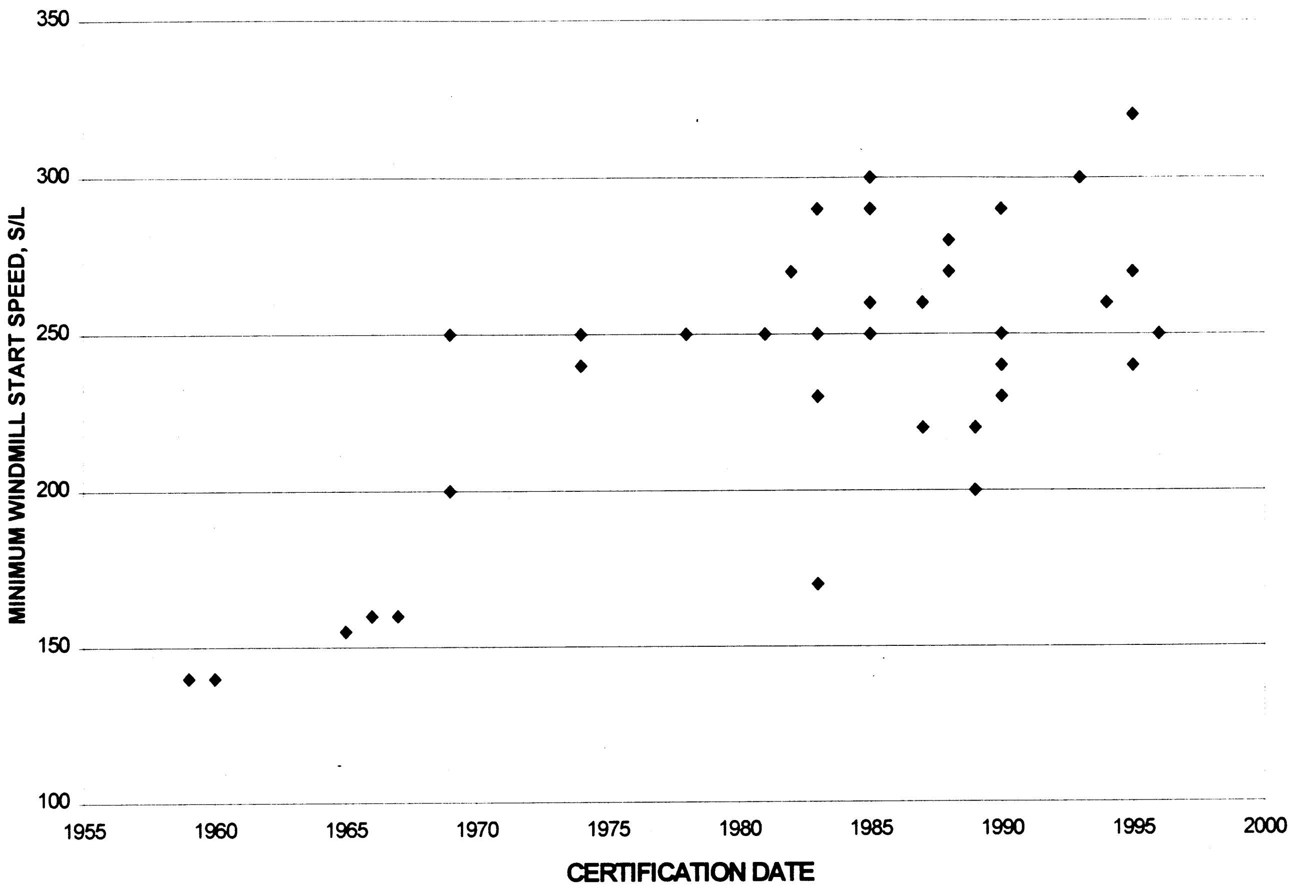

5.00E-07
4.50E-07
4.00E-07
3.50E-07
3.00E-07
2.50E-07
2.00E-07
1.50E-07
1.00E-07
5.00E-08
0.00E+00
1960 TO 1964
1965 TO 1969
1970 TO 1974
1975 TO 1979
1980 TO 1984
1985 TO 1989
1990 TO 1994
1995 TO 1998
ALL-ENGINE POWER LOSS EVENTS/DEPARTURE
HIGH BYPASS FLEET EVENTS/DEPARTURE

CHART 2
Commercial Transport Fleet All-Engine Power Loss Events, by Flight Phase
1960-1996



Majority of events occur at high/intermediate altitudes. Low altitude/low airspeed/low power scenario (condition 4) represents no events/ a very small proportion of events

Chart 3
Certified Windmill Start Envelopes



AlliedSignal
AEROSPACE

AlliedSignal Inc.
AlliedSignal Engines
P.O. Box 52181
Phoenix, AZ 85072-2181

602 231 1000

November 2, 1999

Refer to: E:WCM:1215:110299

Mr. G.P. Sallee
Boeing
9725 East Marginal Way
Seattle, WA 98108

Mr. J.C. Tchavdorov
Airbus Industrie
1 Rond Point Maurice Bellonte
31707 Blagnac Cedex, France

Subject: **AlliedSignal Engines & Systems Comments on Proposed §25.903(e)**

Dear Sirs:

While AlliedSignal Engines & Systems (E&S) is sympathetic with the need for an all engines out in-flight restart requirement, E&S believes that the materials presented for the revised §25.903(e) are inadequate and should not be submitted as a PPIHWG endorsed position to the Transport Aircraft & Engines Issues Group. We also submit that this proposal is not appropriate for the fast-track process and should be tasked as a full rule-making project.

Rationale for this conclusion include:

1. The submitted materials rely on material developed by the AIA/AECMA Inflight Restart Committee (PC345). This effort was prematurely terminated and its report submitted as a statement of status before there was technical agreement amongst the membership. The minority opinions or negative comments received on this rulemaking proposal are evidence of the lack of technical agreement.

2. There seems to be confusion among the members with regard to the status of the NPRM.

3. The proposed new rule language (assuming the version from AIA/AECMA report is current), **"[f]or turbine engine powered airplanes, it must be shown by test and analysis that a means to restart those engines needed for continued safe flight and landing of the airplane is provided following the flame out or shutdown of all engines,"** is inappropriately vague. The rule does not define the conditions that resulted in the "flame out or shutdown of all engines." One or more of the engines may be damaged or not re-startable. There is no definition of the environmental conditions or minimum altitude at which the all engines shutdown condition might have to be recovered from. There is no exclusion for fuel exhaustion. The rule should clearly define the minimum safety standard by clearly specifying the condition(s) that must be addressed.

4. The draft Advisory Circular distributed to the PPIHWG contains a significant amount of regulatory material. Examples of this language include (but are not limited to):

   - Section 7: "Four conditions are to be addressed."
   - Section 7: "Each zone must be identified in the Airplane Flight Manual. Sufficient tests must be carried out in each zone to validate it reliably."

- Sections 8.3 and 8.4" "The same *criteria* as in §8.2 should be used for times to relight and spool-up." (Italics added for emphasis.)
- Section 8.5: "...for compliance with any of the section 7 restart conditions..."
- Section 8.5: "- a minimum of 95% APU start reliability must be demonstrated by test..."
- Section 8.5: "- if an APU assisted engine start is used for complying with the low altitude conditions I or IV...:

In addition to the above concerns, E&S offers the following technical comments on the proposed Advisory Circular.

1. Section 7: The statement "...the applicant will be expected to show by test or analysis supported by tests..." is inconsistent with the proposed rule language, "...it must be shown by test and analysis..." The rule language should be modified to allow either test or validated analysis.

2. Section 7, item 4: The text indicates that credit may be given for aircraft safety devices that minimize the likelihood of the all engines out condition ("aircraft design features which minimize the potential for inadvertent shutoff", automatic relight, and automatic sub-idle stall recovery systems). However, there is neither additional guidance for the applicant on this subject, nor is this credit reflected in the "Acceptable Means of Compliance" listing in the table summarizing the compliance guidelines. Finally, there is no indication that the applicant can obtain similar credit for the presence of these safety systems for the other proposed compliance conditions. The summary table should be modified and credit for such systems should be extended to the other proposed conditions. Furthermore, there has been no substantive regulatory action taken to require that cockpit design preclude known historical causes of flight crew inadvertently shutting down last operating engine through the "normal" engine shutdown means. More emphasis should be directed to preventing the "all engines out" condition, not putting the primary focus on correcting this condition after it has happened.

3. Section 7, Item 4: No rationale is given for using 1.45 V_{stall} (clean configuration) as the initial speed for the proposed condition. The typical flight speed for approach at 10,000 ft should be used as the initial speed. STOL aircraft with low V_{stall} (clean configuration) would be at a regulatory disadvantage. This speed should be increased to at least 250 KT.

4. Section 7: Condition IV in the summary table calls for a 250 KT maximum initial speed for the demonstration based on this being the maximum permitted airspeed below 10,000 ft altitude. However, there is ongoing activity to alter this restriction and this should be reflected in this proposed condition if the condition is retained.

5. Section 8.2: Positive indication of normal start progression should be sufficient to demonstrate acceptable windmill starting capability. The time requirements should be removed from this section.

6. Section 8.3: The proposed fuel interruption of "not less than 30 seconds" for rapid relight demonstration is inconsistent with the proposed recognition times under Section 7, Item 1 (5-15 seconds) and Section 7, Item 4 (30 seconds or less), where rapid relight is an acceptable means of compliance. The fuel interruption or recognition times from Section 7 should be used in Section 8.3.

7. Section 8.3: Text proposes rapid relight demonstrations should be performed with "engine initially stabilized at idle." There seems to be no justification for setting the engine power at "idle."

8. Section 8.6(b): The text "the engine should relight and reaccelerate to its original power without any crew actions other than selecting ignition and fuel" assumes a particular cockpit design. This text should be deleted.

E&S remains committed to the development of a regulatory requirement for all engines out in-flight restart. However, due to the concerns outlined above, we can not support the current proposal at this time. Instead, we recommend that this project be removed from the fast-track process and tasked as a full, cooperative government-industry rule-making project. Furthermore, this rule should not be implemented without regulatory harmonization with the Joint Airworthiness Authorities (JAA).

Sincerely,

Bill Moring

Bill Moring
Engineering Manager
Airworthiness and Certification
AlliedSignal Engines and Systems

WCM/sd

SUBJECT: Cessna Minority Position on Draft AC/ACJ 25.903(e)

DATE: August 19, 1999

TO: **P. Sallee**

FROM: **B. Miles/R. Barnes**

cc: R. Girardo
N. Anderson

The Cessna minority position on this AC/ACJ addressing in-flight restarting is as follows:

A. Revise Section 4.1 paragraph discussing 25.903(e) compliance as follows for accuracy:

Change " many turboprop airplanes utilize electric starters" to "many smaller turboprop and turbojet/turbofan airplanes utilize electric starters".

Change "and utilize pneumatic starters" to "and larger turboprop and turbojet/turbofan engines utilize pneumatic starters:.

B. In Section 5, based on the definitions of relight and restart in a) and b), change "Relight Envelope" to "Restart Envelope" in c) and d) to better reflect the intended meaning.

C. For Section 7 Condition I, Minimum Clean configuration speed is not a well defined or universally recognized speed. It is not believed that it is intended or appropriate to require extremely low speeds such as in or near the stickshaker regime. Since the airplane will be out of the airport environment, by virtue of the allowable 2500 foot altitude loss, and since the restart attempt may not occur until a second engine shutdown following an earlier first engine shutdown, it is requested that Minimum Clean Configuration speed be changed to V_{ENR}.

D. In Section 7, Condition I, clarification is requested as to whether the demonstration altitude should be the most critical altitude selected by the applicant, or whether multiple altitude demonstrations are required.

E. In Section 7, clarification is requested as to whether Condition III consists of both a climb and descent condition, or either a climb and descent condition, whichever is determined to be more critical.

F. In Section 7, Conditions II, III (descent), and IV, the power or thrust at shutdown needs to be clarified. It could be interpreted as either idle or typical descent power or thrust.

G. In Section 7, para 4) allows consideration of other factors, such as dedicated engine shutdown indication, aircraft design features which minimize the potential for inadvertent shutdown, or automatic relight and automatic sub-idle recovery systems, for evaluation of crew recognition time for condition IV. Other than dedicated engine shutdown indication, these factors have little to do with crew recognition time, rather they prevent the shutdown or the need for a flight crew initiated restart if they work properly. The intent of this guidance is unclear. Since these provisions can provide superior safety to crew procedures in low altitude situations, it is recommended that they be recognized as an alternative to low altitude all engine restart, providing they are appropriately addressed per 25.901(c)/25.1309. These factors and the comments above are equally applicable to condition I.

H. In Section 7, Condition IV, the 250 KCAS maximum airspeed should be deleted as unnecessary and redundant to other requirments, in particular the altitude loss. The 250 KCAS speed limit may not be applicable in all parts of the world, and is certainly a trivial operational consideration in an all engine out emergency situation compared to the necessity of a restart. It is recognized that higher speeds may not be practical for all aircraft, while still meeting the other requirements, but this should be an application specific issue rather than a blanket requirement.

I. In Section 8.1, the statement that sufficient tests must be carried out to validate the start envelope reliably is likely to lead to disagreement as to what is sufficient. An additional related issue is whether the engine is required to start successfully the first time, every time, especially at high altitudes exceeding the AC requirments and/or when starting with latent failures present such as an ignitor failure. The following additional guidance is suggested to address these issues.

Three demonstrated starts are normally sufficient at critical points in the starting envelope, however only one need be a simulated all engine out situation where altitude loss is measured. Critical points generally involve low airspeeds, high altitudes, or high ITT/EGT at start initiation. One demonstrated start is sufficient at other points. More than one start attempt, either automatic or manual, is acceptable, provided that the specified altitude loss is not exceeded, that adequate crew recognition of the unsuccessful start attempt is available, and that any external energy source used is not depleted. Multiple start attempts in situations where compliance with altitude loss requirements is marginal may require additional demonstrations to ensure consistency.

J. In Section 8.3, The guidance for rapid relight starts with 30 second recognition delay and idle power at engine shutdown should be revised to be consistent with the rapid relight conditions specified for Section 7 Condition I takeoff scenario.

Saint-Martin, 13 September, 1999
AI/EV-T 474.0646/99/JJO/SC

AI/EV-T

TO

BOEING Propulsion - G.P. SALLEE
AI/LE-P – JC. TCHAVDAROV
FAA - M. KASZYCKI

SUBJECT : LATEST DRAFT ON INFLIGHT RESTART ACJ

The draft ACJ on inflight restart produced by the AIA/AECMA group has been recently amended to take into account JAA comments. One paragraph has been added concerning the requirements that the APU must satisfy in terms of restarting reliability if it is used as a means of compliance for main engine inflight restart.

In the ACJ, an APU restart is considered successful if it is achieved in 2 attempts at the most (see attachment 1).
This is different from the definition of a successful APU restart in the context of ETOPS, where 3 attempts have been allowed, explicitly by the French Airworthiness Authorities (see attachment 2) and implicitly by the FAA (see attachment 3).

I see no benefit for having 2 different definitions of a successful APU restart, one for ETOPS and another one for engine airstart, and I would recommend that we harmonize according to the ETOPS rule, unless somebody comes up with a good reason to do otherwise (Sorry for reacting so late but I wanted to get the attachments and they were not in my possession).

Regards,

J. JOYE

ARAC - PPIHWG
Airbus / Aerospatiale Comments on the "Package"

JAR/FAR 1 – FIRE PROOF/RESISTANT DEFINITIONS REPORT

1st page, last paragraph : not only Titanium, but also some Steels could be in the same situation. (Same remark on 3rd page, end of 2nd paragraph).

1st page, last paragraph, last sentence : add ".... will maintain **sufficient** load carrying capability..."

3rd page, 3rd paragraph : with respect to "perform their intended function", current work on AC 25.865 (2001 ?) should be in line with our efforts.

Para 5 : should be "minimum **capability during a defined time period**", and not "minimum time period".

Para 13 : "No", we need also an AC on "perform their intended function".

25.901(d) – APU REPORT

Delete Title "Harmonization ... ... Appendix I".

1st Paragraph : with respect to essential APUs, the wording should include "... **only if necessary for the dispatch of the aircraft to maintain safe aircraft operation**."

1st Page bottom and second page top : The european rule is JAR "**Subpart J**" and not JAR-J.

Para 12/13/14 : Action for APU Team members. *(H D Hansen's letter sent to Team members).*

25.903(d)(1) – BURNTHROUGH REPORT + AC

Para 6.C : Definition of "Continued Safe Flight and Landing" : should be consistent with 25.1309 definition, we have not to invent something different.

15 ° aft trailing edge of last HPT blade : although this definition is very clear, we believe that the threat of 3000°F is too severe between combustor end and this point when no specific indications are given by the Engine Manufacturer for the application under certification.

25.903(e) – RESTART REPORT + COMMENTS

No specific comment on the Report. The draft AC is in some areas stronger than it should be as an interpretative material : an example is the compliance to be shown by test or analysis supported by test, whereas the rule leaves the choice of demonstrating by analysis or test.

AI (J. Joye) comment agreed by the Steering Committee in Montreal, to be included in the AC.

GE (Sara Knife) comment rejected by the Steering Committee in Montreal. In general AI/AM-B disagree with most GE comments.

Most of the Cessna comments (B, D, E, G, H, J) are judged good by AI/AM. Those can certainly be incorporated without altering the technical content of the AC.

P&W comments are more controversial. To AI/AM-B, the 3 first items of "Rationale" are not relevant : 1 and 2 are useless polemics, 3 is not true (the proposed language is not any more vague than so many rules !), 4 can be discussed (see first comment here above). Then, the P&W technical comments are addressed as follows :

- 1 is details,
- 2 can be accepted,
- 3 is okay, it is proposed that the text in section 7 be modified to be consistent with section 6.1,
- 4 could be discussed,
- 5 : green dot, holding speed,
- 6 can be discussed when relevant,
- 7 : see below (*),
- 8 : comment not understood,
- 9 could be discussed,
- 10 is agreed.

Finally, AI/AM-B disagree with P&W position that the task should be removed from the Fast-Track process to be tasked as a full rule-making process.

(*) With respect to the noticed discrepancies in Section 7, Paragraph 4 (see below), this text was modified during the last AIA/AECMA meeting in Seattle (July 98) in order to reach a consensus with the small engine manufacturers. A simple way to restore the coherence of the text is to go back to the pre-Seattle version as shown just below.

"4) Flame out or shut down from descent power below 10,000ft with a delay in crew action based on indications (inherent or dedicated indicators) to the flight crew of all engine power loss.
A 30 second crew recognition time should be used if no dedicated indication is provided. Crew Recognition Time may be shortened based upon dedicated indications that engines have flamed out or rolled back to sub-idle.~~, as well as aircraft design features which minimize the potential for inadvertent shutoff. Other factors which may be considered in the crew recognition time evaluation include automatic relight and automatic sub-idle stall recovery systems.~~
The initial airplane speed that should be used for the all-engine out restart evaluation is 1.45V stall (clean configuration) of the maximum landing weight of the aircraft. Acceptable means of compliance include rapid relight, starter assistance from an external
source and stabilized windmill start. The airplane should not lose more than 5000 feet altitude between initiating restart procedures and achieving level flight. In addition, the maximum aircraft speed to achieve the restart should not exceed 250kts."

25.905 – PROPELLER BLADE RELEASE REPORT + AC

No specific comment.

25.933- THRUST REVERSER Package

No Further Action.

25.934 – THRUST REVERSER TEST REPORT

JAR E Reference is **890** (and not 810) : 7 times in the document.

25.943 – NEG G REPORT + AC

Page 3 : JP4 is not necessarily always the most critical case for pump cavitation issue.

Page 4, Procedure : the 1st two conditions represent 7 and 5 seconds respectively; the total being 20 s, what should be the procedure for the last remaining 8 seconds ?

AI/BAe comment : the procedure as per ACJ 25X1315 is currently utilized by Airbus and approved by the FAA. What is the need to go to the proposed procedure ? As a compromize, if required, why not to propose to leave to the applicant the choise between one procedure (FAA AC25-7) or the other (JAA ACJ 25X1315), the 2 procedures being considered equivalent.

Para 7 : **add 25.943.**
Report Para 2 : add **JAR 25A943 and its ACJ.**
Report Para2 : correct JAR 25**X**1315 and not 25.1315.

25.1091 – WATER INGESTION TEST REPORT

Para 1 : "**recommends**" instead of "….is mandatory and requires…".

Para 6 : Delete current text. "**JAR/FAR Rule is harmonized. Advisory Material to be harmonized with JAA ACJ.**"

Para 7 : "**advisory material**" instead of "requirements" at the end of the text.

Para 12 : "**None**" instead of the current text.

Para 13 : "**No. The JAA ACJ 25.1091(d)(2) should be adopted.**"

25.1093 - FALLING AND BLOWING SNOW REPORT +AC

1st page, B.1 : correct "JAR 25…."

ACJ Para 2.f.1) : add "**If potential snow accumulation sites are identified, then the assessment should be expanded to include 2) and 3) below**."

25.1141 - POWERPLANT CONTROLS REPORT

Para 6 : The "Preferred" proposal is preferred by Airbus/Aerospatiale.

Para 6 : The text in italics after the rule ("*In addition, preamble material should ....1) 2) 3)...*" should be not in the preamble, but in a short AC/ACJ to be written.

25.1189 - FLAMMABLE FLUID SHUT-OFF REPORT +AC

AC Last page, last sentence : replace current text by the following "**If the analysis of drainage rate, per the guidance of AC 25.1187, shows that the fluid volume will drain within an additional 5 minutes, then fluid quantity can be considered to be non-hazardous without further hazard assessment.**"

Appendix I – ATTCS REPORT + COMMENTS

No specific comment.

Airbus Industrie / Aerospatiale-Matra Airbus (AI/AM-B)
November 4, 1999

k) Rapid Relight/Quick Windmill Relight : A procedure in which the pilot executes a windmill start shortly after the engine has been shut down, so that the core speed is significantly above stabilized windmill speed.

6 - DESIGN CONSIDERATIONS

6.1 - Auto-adaptive systems

Several manufacturers have implemented features which are intended to enhance safety by reducing the likelihood of engine damage during start or eliminating all engine flame-out events for specific causes. These systems may improve safety but should not be considered as eliminating the need for a safety evaluation of all engine power loss occurrences. The following are methods Airworthiness Authorities are currently aware of :

Autostart Systems :

This feature is intended to protect the engine from damage due to a hung start. These systems are typically software controlled (FADEC) and monitor the engine start to assure limits are not exceeded during the start sequence. Typically fuel flow is interrupted ("depulsed") if the Exhaust Gas Temperature (EGT) reaches the defined limit. No specific indication may be provided to the crew that the depulse feature has been activated, however the crew may detect its activation by monitoring fuel flow, EGT and rotor speeds. This system will attempt multiple restarts inflight unless the crew intervenes and switches to the manual mode or the system will alert the crew if it discontinues attempts to restart the engine.

Auto Relight Systems :

These systems typically activate the engine ignitors if the engine rapidly decelerates and a reduction in engine combustor pressure (or EGT/fuel flow below specified levels) is sensed. These systems are generally used to recover from engine flameout in turbulent conditions and inclement weather.

6.2 - Cockpit Indications

Service history has shown that in some instances flight crews have not been aware that the engine was below idle power until the engine failed to respond when the throttle was advanced.

Conversely, during engine airstarts, flight crews have aborted start attempts that would have been successful, or shut down engines that had successfully reached idle. As a consequence :

1) Consideration should be given to providing the crew with indication(s) that the engine has flamed out and/or is at a sub-idle condition.

2) Consideration should be given to providing the crew with indication(s) that inflight restart is progressing normally in addition to indications of start faults.

3) Consideration should be given to providing the crew with indication(s) that the engine has reached idle following an inflight restart.

7 - COMPLIANCE GUIDANCE

This section is intended to define overall restart performance that includes the use of power assisted and windmill restart capabilities and to describe acceptable compliance guidelines.

DRAFT 8/16/99

PPIHWG Report on 25.903(e) – Inflight Starting

1. What is the underlying safety issue addressed by FAR/JAR? *[*Explain the underlying safety rationale for the requirement. Why does the requirement exist?*]*

The total loss of all propulsive power, malfunction of all engines installed on an airplane, for environmental, human error and other causes has occurred. The actual capability to inflight restart one or more engines, after all engine flameout or are shutdown, has provided the capability to avoid forced landings and the potential for severe consequences. However, engine certification standards are silent on a requirement to demonstrate a minimum inflight engine re-starting capability. The airplane certification requirements, whilst requiring that an inflight re-starting capability be demonstrated, do not establish a minimum standard for the required capability in terms of altitude, altitude loss and airspeed range given all engines have been lost. Lack of an explicitly defined inflight re-starting minimum safety standard has resulted in wide variation in the inflight engine re-starting capabilities. Some turbine engine types have no inflight windmilling re-starting capability at all and alternate means for inflight re-starting have been required under special condition. This regulatory proposal present in this Report is to amend the regulation to clearly address the all engine out failure condition and provide a minimum inflight re-starting capability to be achieved and a means to demonstrate compliance by the addition of a new rule and associated advisory material.

2. What are the current FAR and JAR standards? [*Reproduce the FAR and JAR rules text as indicated below.*]

"FAR part 25.903(e)

Restarting capability. (1) Means to restart any engine in flight must be provided (2) An altitude and airspeed envelope must be established for in-flight engine restarting, and each engine must have a restart capability within that envelope. (3) For turbine engines powered airplanes, if the minimum windmilling speed of the engine following the inflight shutdown of all engines, is insufficient to provide the necessary electrical power for engine ignition, a power source independent of the engine-driven electrical power generating system must be provided to permit in-flight engine ignition for restarting."

JAR 25.903(e) is identical to the FAR wording except for a reference to ACJ 25.903(e)(2) in the second subparagraph.

This Report proposes to adds a new 25.903(e)(4) requirement and associated Advisory Material.

3. What are the differences in the standards and what do these differences result in? [*Explain the differences in the standards, and what the differences result in relative to (as applicable) design features/capability, safety margins, cost, stringency, etc.*]

The are no differences in the stated standard as shown in #2 above. Both standards do not adequately describe the minimum inflight restarting envelope of airspeed and altitude standard to be demonstrated given an all engines out situation (and no capability to use starter assist using pneumatic power from other engines on the airplane). Further the current standards to not provide a performance standard to be achieved with respect to altitude loss during the inflight re-start.

4. What, if any, are the differences in the means of compliance? [*Provide a brief explanation of any differences in the compliance criteria or methodology, including any differences in either criteria, methodology, or application that result in a difference in stringency between the standards.*]

A proposed means of compliance is provided in the associated Proposed AC.

5. What is the proposed action? [*Is the proposed action to harmonize on one of the two standards, a mixture of the two standards, propose a new standard, or to take some other action? Explain what action is being proposed (not the regulatory text, but the underlying rationale) and why that direction was chosen.*]

The proposed action is to establish a new rule and means of compliance which directly deal with the safety concern.

6. What should the harmonized standard be? [*Insert the proposed Text of the harmonized standard here.*]

See attachments – draft NPRM, rule and advisory material.

7. How does this proposed standard address the underlying safety issues (identified under #1? [*Explain how the proposed standard ensures that the underlying safety issue is taken care of.*]

The proposed rule requires that the "all engine out failure conditions" be addressed under four critical conditions likely to be encountered in service. Performance based success criteria concerning altitude loss during inflight re-starting is described. Additionally, the entry conditions for each in-flight restarting demonstration are defined. Given the airplane is demonstrated to have this engine restarting capability the safety objective, of minimizing the hazard associated with all engine out conditions, will be achieved

8. Relative to the current FAR, does the proposal increase, decrease or maintain the same level of safety? Explain. [*Explain how each element of the proposed change to the standard affects the level of safety relative to the FAR. It is possible that some portions of the proposal may reduce the level of safety even though the proposal as a whole may increase the level of safety.*]

Adoption of the proposal will increase safety relative to the current rule but is neutral given the current Generic Special Condition issued against all new airplane types for this safety concern.

9. Relative to current industry practice, does the proposed standard increase, decrease, or maintain the same level of safety? Explain. [*Since industry practice may be different that what is required by the FAR (e.g., general industry practice may be more restrictive), explain how each element of the proposed change to the standards affects the level of safety relative to current industry practice. Explain whether current industry practice is in compliance with the proposed standard.*]

The proposal maintains current practice.

10. What other options have been considered and why were they not selected? [*Explain what other options were considered and why they were not selected (e.g., cost/benefit, unacceptable decrease in the level of safety, lack of consensus, etc.)*]

The proposal was developed at the request of the FAA toAIA as a AIA/AECMA activity/project. The completion of this Industry Project led to a petition for rule making. The current proposal makes use of the AIA/AECMA proposal amended to incorporate some JAA and JAA-PPSG (Powerplant Study Group) comments.

11. Who would be affected by the proposed change*?*[*Identify the parties that would be materially affected by the rule change – airplane manufacturers, airplane operators, etc.*]
Airplane manufacturers, STC applicants for installation of a different engine type on an airplane, and engine manufacturers.

12. To insure harmonization, what current advisory material (e.g., ACJ, AMJ, AC, policy letters) needs to be included in the rule text or preamble? [*Does the existing advisory material include substantive requirements that should be contained in the regulation? This may occur because the regulation itself is vague, or if the advisory material is interpreted as providing the only acceptable means of compliance.*]

None. The added rule and supporting AC/J require no other changes. However, the preamble to the rule should clearly define that the AC contains interpretative material intended to establish the minimum safety standard.

13. Is the existing FAA advisory material adequate? If not, what advisory material should be adopted? [*Indicate whether the existing advisory material (if any) is adequate. If the current advisory material is not adequate, indicate whether the existing material should be revised, or new material provided. Also, either insert the text of the proposed advisory material here, or summarize the information it will contain, and indicate what form it will be in (e.g., Advisory Circular, policy, Order, etc.)*]

Not applicable – The new rule and advisory material are additive and do not interfere.

14. How does the proposed standard compare to current ICAO standard? [*Indicate whether the proposed standard complies with or does not comply with the applicable ICAO standards (if any)*.]

Help! FAA/JAA to answer.

15. Does the proposed standard affect other HWG's? [*Indicate whether the proposed standard should be reviewed by other harmonization working groups and why*.]

No.

16. What is the cost impact of complying with the proposed standard? [*Is the overall cost impact likely to be significant, and will the cost be higher or lower? Include any cost savings that would result from complying with one harmonized rule instead of the two existing standards. Explain what items affect the cost of complying with the proposed standard relative to the cost of complying with the current standard.*]

Cost implications have already been addressed by the Generic Special Condition and given that the Special Condition was considered necessary the new rule and AC only clarify and standardize the requirements and no additional cost should be involved.

17. Does the HWG want to review the draft NPRM at "Phase 4" prior to publication in the Federal Register?

Yes.

18. In light of the information provided in this report, does the HWG consider that the "Fast Track" process is appropriate for this rule making project, or is the project too complex or controversial for the Fast Track Process. Explain? Explain. [A negative answer to this question will prompt the FAA to pull the project out of the Fast Track Process and forward the issues to the FAA's Rulemaking Management Council for consideration as a "significant "project.]

. *Yes*

Revision dated 8/12/99

AC / ACJ 25.903(e)

ENGINE RESTART CAPABILITY DEMONSTRATION FOR TRANSPORT CATEGORY AIRPLANES

1 - PURPOSE

This Advisory Circular (AC) provides information and guidance concerning a means, but not the only means, of compliance with section 25.903(e) of Part 25 of the Federal Aviation Regulations (FAR) which pertains to engine restart capabilities of Transport Category Airplanes. Accordingly, this material is neither mandatory nor regulatory in nature and does not constitute a regulation. In lieu of following this method, the applicant may elect to establish an alternate method of compliance that is acceptable to the Federal Aviation Administration (FAA) for complying with the requirements of the FAR sections listed below.

2 - SCOPE

This Advisory Circular provides guidance for a means of showing compliance with regulations applicable to engine restart capability in Transport Category Airplanes. This guidance applies to new airplanes designs as well as modifications to airplane or engine designs that would adversely affect engine restart capabilities.

3 - RELATED FARs and JARS

FAR Part 25, sections, 25.903(e), 25.1351(d), 25.1585(a)(3), JAR 25.903(e), JAR-E910, FAR 33.5(b)(3) and 33.89(a)(1).

4 - BACKGROUND

4.1 - Regulatory history

The inflight engine restart requirements for turbine powered airplanes are identified in §§§ 25.903 and 25.1351 and 25.1585 of the Federal Aviation Regulations (FAR). Sections 25.903 and 25.1585 requirements were developed from the engine inflight restart requirements of the earlier Civil Air Regulations (CAR) Part 4b. Paragraph 4b.401(c) required the ability for individually stopping and restarting the rotation of any engine during flight.

This intention was further incorporated into Part 25, specifically § 25.903(e), which requires 1) the ability to restart any engine during flight must be provided; 2) an altitude and airspeed envelope must be established for inflight engine restarting, and each engine must have a restart capability within that envelope; and 3) if the minimum windmilling speed of the engines following the inflight shutdown of all engines, is insufficient to provide the necessary electrical power for engine ignition, a power source independent of the engine driven electrical power generating system must be provided to permit inflight engine ignition for restarting. In addition, Section 25.1351(d) requires demonstration that the airplane can be operated for 5 minutes following the loss of all normal electrical power (excluding the battery) with the critical type fuel (from the standpoint of flame out and restart capability) and with the airplane initially at the maximum certificated altitude. For airplanes equipped with Alternating Current (AC) powered fuel pumps that are powered from the engine electrical generators, this requirement has resulted in demonstration of the capability to windmill relight the engine while on suction feed with battery power for ignition. Relight of the engines has typically occurred at altitudes between 16,000 and 25,000 feet. In addition, as stated earlier in CAR 4b.742(d), the recommended procedures to be followed in restarting turbine engines in flight are to be described, including the effects of altitude. This intention was also incorporated into Part 25, specifically § 25.1585(a), which states that information and instruction must be furnished, together with recommended procedures for restarting turbine engines during flight (including the effects of altitude).

There are no explicit inflight restarting requirements imposed on the engine in FAR 33 or JAR-E. Nevertheless there are requirements to define starting procedures (33.5(b), **33.89, E910) and to recommend an envelope (E910).**

Compliance with § 25.903(e) has been shown by establishing that adequate engine restart capabilities exist for the various engine types installed on transport category airplanes. **For example, many turbopropeller airplanes utilize electric starters that allow restart of** the engine throughout the airplane airspeed and altitude flight envelope. Compliance is therefore easily shown by flight test demonstration of restart capability and analysis to show availability of electrical power for the starter. Turbo jet/turbo fan engines typically have windmill restart capability that is effective throughout a portion of the flight envelope, and utilize pneumatic starters to achieve restart throughout the remainder of the envelope. Compliance demonstration for these airplanes have included establishing both a windmill and a starter assist restart envelope. In several instances the windmill restart envelope has been limited to a small portion of the flight envelope. Applicants have utilized supplemental restart means, such as an essential APU installation to supply pneumatic power for restart to substantiate compliance.

Lack of an explicitely defined inflight restarting minimum standard has resulted in wide variations in the restart capabilities of transport category airplanes. Some newer technology engines require several minutes at airspeeds above 250kts to windmill restart.

In addition, some turbopropeller engines with free turbines have limited or no windmill restart capabilities within the normal airplane operating envelope. On certain airplane types that are not equipped with means to assist restart, reduced engine restart capabilities could result in an unsafe condition following an all-engine flame out event at mid to low altitudes.The altitude loss required to obtain sufficient airspeed for a windmill restart, in conjunction with the associated long restart times, may not allow restart prior to reaching ground level.

4.2 - <u>Service History</u>

Since the beginning of aviation, all-engine power loss incidents have occurred. Incidents have been reported on almost every airplane type for various reasons such as fuel mismanagement, loss of electrical power, crew error, mis-trimming of engine idle setting, fuel nozzle coking, volcanic ash encounters, and inclement weather. The FAA has determined that the all-engine power loss event must be considered in airplane design.

Section 25.671 requires that the flight controls be designed such that control of the airplane can be maintained following the loss of all engine power. The service experience supports the position that suitable engine restart capability must be available following the loss of all engine power to avoid an unsafe condition.

4.3 - Industry Restart Data

Industry historical records contain many (at least 30 events in the period 1982 up to 1993) multiple engine power loss events.

These records show all-engine power loss events that jeopardized continued safe flight have occurred (over the altitude range) for the following reasons :

Weather	(Low Altitude to FL410)
Volcanic Ash	(FL370, FL330, FL250, low altitude possible)
Crew error	**(FL030 to FL410)**
Compressor Surge	(Takeoff to cruise altitude)
Maintenance Error	(Takeoff to cruise altitude)
Other/Unknown	(Takeoff to cruise altitude)

It does not appear that it is possible to define in advance all of the potential causes for critical power loss and/or preclude their occurrence. Thus it is necessary to define what engine restart capabilities are required to maintain the current level of safety.

5 - DEFINITIONS

a) Relight : The combustor lights off and sustains combustion.

b) Restart : The engine has accelerated to stabilized flight idle.

c) Windmill Relight Envelope : The portion of the airplane airspeed/altitude envelope where the engine is capable of being restarted without starter assistance.

d) Power Assisted Relight Envelope : The portion of the airplane airspeed/altitude envelope where the engine requires starter assistance to achieve restart.

e) Auto Ignition System : A system that automatically activates the engine ignitors if pre-determined conditions apply (e.g., ice detectors indicate icing conditions, flaps are configured for approach/landing, etc.).

f) Auto Start System : A system that monitors engine parameters during starting and automatically sequences fuel flow accordingly. It may include logic protecting against turbine temperature limit exceedance and sub-idle stall, among other features.
It reduces pilot work load by eliminating the need to manually turn fuel on at a given core speed and to monitor the speed/turbine temperature relationship during the start.

g) Auto Depulse Logic/Stall Recovery Logic : Logic incorporated into the engine control that momentarily shuts off fuel flow to clear an engine stall.

h) Auto-Relight : A feature which monitors the operation of the engine to attempt to recover an engine flameout. In its most basic form, it is equivalent to automatically selecting continuous ignition. When the engine control senses that an engine has flamed out (by rotor speed decay, a drop in combustor pressure, or other means), it turns on the ignitors.
Auto-relight typically reacts much more quickly to a flame out than a pilot could.

The effects of the loss of engine power from one, multiple and all engines must be considered. However, the loss of all engines generally determines the most stringent requirements in terms of restart capability, and the intent of the regulation will be satisfied by addressing this critical case.

In order to confirm that engine restarting can be achieved, in circumstances where all engines run down or are shut down, the applicant will be expected to show by test or analysis supported by tests that sufficient power/thrust can be restored to enable the airplane to achieve level flight without excessive loss of altitude.

Four conditions are to be addressed :

1) Shut down from take off/climb power with pilot recognition time delay based on analysis of indications (inherent or dedicated indicators) to the flight crews (Pilot recognition time has typically ranged from 5 to 15 seconds based on service data).
Acceptable means of compliance include rapid relight procedures or starter assistance from an external power source. The altitude loss between initiating the restart and achieving level flight should not exceed 2500ft.

2) An engine should be able to be restarted at a minimum altitude of 15,000ft from a shut down at typical descent speed at 20,000ft or above.

3) The engine should be able to be restarted with an altitude loss not exceeding 5000ft from a power loss occurring between 10,000 and 20,000 feet.

   The aircraft speed at the time of power loss should be representative of the normal flight profile (climb or descent) in this altitude range for the flight phase considered.

4) Flame out or shut down from descent power below 10,000ft with a delay in crew action
based on indications (inherent or dedicated indicators) to the flight crew of all engine power loss.
A 30 second crew recognition time should be used if no dedicated indication is provided.
Crew Recognition Time may be shortened based upon dedicated indications that engines have flamed out or rolled back to sub-idle, as well as aircraft design features which minimize the potential for inadvertent shutoff. Other factors which may be considered in the crew recognition time evaluation include automatic relight and automatic sub-idle stall recovery systems.
The initial airplane speed that should be used for the all-engine out restart evaluation is 1.45V stall (clean configuration) of the maximum landing weight of the aircraft.
Acceptable means of compliance include rapid relight, starter assistance from an external source and stabilized windmill start. The airplane should not lose more than 5000 feet altitude between initiating restart procedures and achieving level flight. In addition, the maximum aircraft speed to achieve the restart should not exceed 250kts.

These compliance guidelines are summarized in a tabular form here below :

	I TAKE OFF	II HIGH ALTITUDE	III CLIMB/DESCENT	IV LOW/SLOW
INITIAL ALTITUDE	Approved Takeoff Altitude Range	20 kft +	10 to 20 kft	10kft to landing

8.6 - Additional compliance demonstrations

As a complement to the compliance demonstrations carried out to establish and validate the declared airstart envelope, the capability to restart the engine should be demonstrated in the following particular cases :

a) Restart after engine cold-soak

Some restarts should be carried out within the declared restart envelope after shut down periods of 5 minutes and 15 minutes.

b) Immediate restart after shut down from high power

- The capability to immediately restart the engine after a shut down from max climb power following a take-off should be demonstrated.

- If the means of compliance is a quick relight procedure, the fuel interruption should last typically 5 to 15 seconds depending on indications available to the crew (as stipulated in section 7), and the engine should relight and reaccelerate to its original power without any crew actions other than selecting ignition and fuel.

c) Restart after suction feed flameout

For airplanes equipped with AC powered booster pumps, the effect of the loss of all normal AC power should be tested.

The test should be conducted using the worst case fuel from an engine flame-out standpoint.
If the fuel volatility is greater than that of Jet A/Jet A1, the fuel should be preheated in mass such that the fuel temperature in the aircraft tank is at least 110° F after refueling.

The capability to restart engines should be demonstrated when the suction feed flame-out occurs at the maximum cruise altitude, and also at the maximum suction feed climb altitude if no alert is provided to deter the crew from climbing above it when operating in gravity feed conditions.

For the maximum cruise altitude case, the test should consist of a straight climb to the aircraft ceiling altitude, where the loss of AC power will be simulated for one engine. If flame-out occurs, the restart of the engine should be attempted with the aircraft configured to be representative of an all engine flame-out condition.

For the suction feed climb case, the loss of AC power should be simulated for one engine immediately after take-off and a continuous climb performed until the engine flames out. The restart should be attempted with the aircraft configured to be representative of an all engine flame-out condition.

For both cases, a successful restart should be achieved prior to reaching 10000ft if the fuel volatility is greater than that of Jet A/Jet A1, or 15,000ft with all others.

ALTITUDE LOSS *	2500 ft	Relight by 15kft	5000 ft	5000 ft
MAX ALLOWABLE AIRSPEED	N/A	N/A	N/A	250 KTS (based on max airspeed below 10 kft)
INITIAL AIRSPEED	***Minimum Clean Configuration*** speed or 250 kts **	Typical descent speed	Normal flight profile (climb or descent speed)	1.45 V stall (clean airplane config.)
RECOGNITION TIME	typically 5 to 15 seconds	N/A	N/A	30 seconds or less depending on indications
ACCEPTABLE MEANS OF COMPLIANCE	Rapid relight or assisted relight from an external source	Stabilized windmill start or starter assist from an external source	Stabilized windmill start or starter assist from an external source	Rapid relight, starter assist from an external power source or stabilized windmill start

* Note Altitude loss measured from initiation of restart procedure
** Note – the lesser of the two speeds

8 - COMPLIANCE DEMONSTRATION

8.1 - General

The restart envelope and procedures declared by the applicant are intended to fulfill the guidelines specified in section 7.

The declared restart envelope will generally consist of several zones.

- One zone where the engine is rotated by windmilling at a sufficiently high RPM to achieve a successful restart. This zone may be subdivided into a stabilized windmill restart envelope and a spooling – down restart envelope (rapid relight).

- Another zone where the engine is rotated with the assistance of a starter to a sufficiently high RPM to achieve a restart.

Each zone must be identified in the Airplane Flight Manual. Sufficient tests must be carried out in each zone to validate it reliably.

8.2 - Demonstration procedure for stabilized windmill airstarts

- Tests should be conducted so that the windmill speed of the test engine is fully stabilized when the target altitude and aircraft speed are reached.

- The engine fuel feed system, hydraulic system and electrical system should be configured to be representative of an all engine flame-out condition.

- The time to relight should not exceed 30 seconds and the spool-up time from relight to idle should not exceed 90 seconds. A longer spool-up time may be acceptable if a positive indication is available to the crew that the start is progressing normally. However the altitude loss associated with the total restart time (from fuel on to idle) in an all engine flame-out condition should not exceed 5000ft, when the restart is initiated at or below 20000ft (as stipulated in section 7).

8.3 - Demonstration procedure for spooling-down windmill airstarts (rapid relight)

- The declared rapid restart envelope should be based on a fuel interruption of not less than 30 seconds. A shorter time may be acceptable if a dedicated engine failure annunciation is provided to the crew.
- Tests should be conducted with the engine initially stabilized at idle. The engine should relight and accelerate to idle without requiring any crew actions other than selecting ignition and fuel.
- The same conditions as in § 8.2 above should be observed for the engine fuel feed system, hydraulic system and electrical system.
- The same criteria as in § 8.2 should be used for times to relight and spool-up.

8.4 - Demonstration procedure for starter-assisted airstarts

- Tests should be conducted so that the windmill speed of the test engine is fully stabilized when the target altitude and aircraft speed are reached.
- The engine fuel feed system, hydraulic system and electrical system should be configured to be representative of the condition of the airplane for the case considered.
- The same criteria as in § 8.2 should be used for times to relight and spool-up.

8.5 Demonstration procedure for APU assisted engine airstarts

If an APU assisted engine airstart is used for compliance with any of the section 7 restart conditions, the following guidelines should be followed:

- the APU installation should be certified as "essential"
- a minimum of a 95% APU start reliability must be demonstrated by test considering:
  - i) maximum APU cold soak appropriate for restart condition being addressed (note that the APU coldsoak associated with the maximum airplane range should be considered for the high altitude cruise condition II and the descent condition IV)
  - ii) a maximum of two APU start attempts shall be allowed for each start condition
  - iii) continuous APU operation throughout the affected flight regime may be used in lieu of demonstrating APU inflight start reliability
- APU start time should be considered in the airplane altitude loss calculation
- In order to maintain the APU's demonstrated start reliability after the airplane is introduced into service, the airplane and APU manufacturer should develop a maintenance program for the APU installation. This maintenance program should include general APU maintenance tasks, periodic checks of the APU's inflight starting capability and a post-maintenance inflight start verification. The critical maintenance tasks, start functional checks, as well as their associated time intervals should be mandated. Consideration of including these items as Certification Maintenance Requirements should be given.
- if an APU assisted engine start is used for complying with the low altitude conditions I or IV (takeoff and descent/landing), then the airplane should incorporate logic which automatically recognizes the all engine powerloss condition and automatically restarts the APU. Further, consideration should be given to also automatically reconfigure the airplane pneumatic and/or electrical system to minimize the crew workload associated with achieving main engine restart during these critical low altitude conditions.